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Mathematics and Gender

By Mark McCormack, Ph.D.

Durham University

For the book: Debates in Mathematics Education

Examining the differences in success at maths between boys and girls is something that we, as a society, seem to find endlessly fascinating. Whether boys or girls are getting more top grades, even by just one percentage point, takes on a special significance, as does the percentage of boys and girls getting a grade C or above. Yet whilst I argue that it is vital to think about gender and maths, it is also worth highlighting the generally small differences in results between boys and girls at mathematics (and, as Andy Noyes and Peter Gates note in their chapter, much smaller than differences by social class). Even so, these results are always seen through a lens of gender difference - of one gender being better than the other.

Highlighting this lens of gender difference sensationalism, despite the marginal differences between boys' and girls' results, 2009 was the first year boys got more of the top two A and A* grades than girls for several years. It was this that became the media story: For example, *The Guardian* newspaper proclaimed, "Boys have leapfrogged over girls in maths GCSE results, bagging more of the top grades for the first time since 1997 after the government scrapped coursework last year" (Curtis 2009). And yet just two years later, a finding that 6.8% more girls than boys were achieving A* and A grades was seen by the Director of the Joint Council for Qualifications as a "growing divide in performance between boys and girls at the top grades" (Shepherd 2011). Seemingly, we cannot avoid looking at gender and mathematics as an issue of boys *versus* girls.

Whilst I have been sceptical of gender differences in results at school level, it is important to recognise the importance of gender in other ways. Primarily, gender differences persist in the take-up of advanced mathematics courses, as well as regarding numbers of men and women who pursue maths-related careers (Gunderson et al 2012). Furthermore,

students' experiences of mathematics – as enjoyable, as interesting, as difficult – are also influenced by gender, and the very idea of mathematics has associations with masculinity (Mendick 2005), and these factors will affect their use of and relationship with mathematics throughout their lives. This means that even if gender imbalances in maths results at school are minimal, we still have to pay great attention to how we deal with gender in the classroom (McCormack 2011).

It is very difficult to think about the difference that gender makes to our own life. Do you think that your personal relationship with mathematics has been influenced by your gender? Do you ever see this influence in other people's relationships to mathematics?

What Gender Differences in Mathematics Exist?

Early studies found significant gender differences in mathematics performance which were then attributed to innate 'ability'. For example, by studying boys and girls identified as gifted and talented in mathematics, Camilla Benbow and Julian Stanley (1980, 1262) argued that there were "large sex differences in mathematical aptitude" between boys and girls, suggesting that environmental influences are a contributing but not primary factor. In a later study, Benbow and Stanley (1983) argued that gender differences were most pronounced in relation to mathematical reasoning, particularly among more 'able' students. Again, they attributed this 'male superiority' to predominantly biological factors, arguing that social factors were unlikely to be the key issue.

These findings proved both newsworthy and contentious, and have continued to influence debates about mathematical ability ever since. Yet great gains have been made over the past several decades, and more recent research has documented few and marginal gender differences in mathematics performance (Hyde and Linn 2006). Furthermore, other research has highlighted that gender differences vary across countries (Else-Quest, Hyde and Linn 2010) - suggesting social reasons are the basis of the few remaining differences.

Moreover, as discussed in the introduction, significant differences do not exist in GCSE results in England and Wales either.

Yet, as mentioned above, results at GCSE are not the whole story. Despite differences in mathematics results at the school level bordering on insignificance, the gendering of mathematics is still of vital importance to understand. The key reason for this is that despite near-equality in academic test scores at school, there are significant disparities in outcomes further down the line. Specifically, fewer women continue to pursue maths at degree level and the careers requiring scientific or quantitative knowledge are still heavily male-biased (Gunderson et al 2012). In order to appreciate how these disparities occur, it is first necessary to understand how gender is constructed and regulated in social life.

If you are currently working within a co-educational school context, are there gender differences in the results of the mathematics classes? What could be the reasons for these?

The Social Construction of Gender

When scholars talk about the social construction of gender, the first thing to highlight is that we are not arguing men's and women's bodies are *literally* created socially. Of course, bodies exist, and no amount of social interaction would change this. But the practices, expectations and meanings ascribed to these different types of bodies are socially constructed, and this has great impact on how we live our lives (West and Zimmerman 1987). The nature/nurture debate is an extremely contentious one and some gender scholars do appear to endorse a view that gender is entirely socially constructed. Such debates have been termed as social determinism versus biological determinism (that is, it is either all social or all biological). In my view, the reality is somewhere between these two poles - society and biology interact to produce these differences (see McCormack 2012).

In a classic article on the construction of gender, Don West and Candace Zimmerman (1987) explain how people actively 'do' gender. They write that gender is 'not simply an aspect of what one is, but, more fundamentally, it is something that one *does*, and

does recurrently, in interaction with others' (p. 140). They highlight that even though the essential characteristics thought to constitute our sex (such as genitalia) are hidden, we are always socially perceived as either male or female. Great emphasis is therefore placed on our *gendered* behaviours - that is, on our behaviours that are coded as masculine or feminine. This is because our gendered behaviours are seen to confirm (or alternatively question) the 'true' status of our sex. All our gendered behaviours and the meanings attached to them are thus framed and distilled through this desire to demonstrate a united sexed and gendered self. Combined with our innate need to conform to social norms (Asch 1951), West and Zimmerman argue that our continual quest to be seen as maintaining the appropriate sex and gender is how we 'do' gender in social interaction.

However, while social interaction is of paramount importance in understanding gender in society, it is also necessary to examine the broader construction of gender. Sociological studies of institutions demonstrate that gender is also a form of power that pervades the social structures of society. Joan Acker (1990) explicates the ways in which organisations are gendered, where 'advantage and disadvantage, exploitation and control, action and emotion, meaning and identity, are patterned through and in terms of a distinction between male and female, masculine and feminine'. As Michael Kimmel (2004, p. 102) argues:

To say that gender is socially constructed requires that we locate individual identity within a historically and socially specific and equally gendered place and time, and that we situate the individual within the complex matrix of our lives, our bodies, and our social and cultural environments.

The notion of gendered organisations also applies to schools. Mairtin Mac an Ghaill (1994) highlighted that schools were 'masculinity-making' institutions, where gender differences between boys and girls are produced and consolidated. From school discourses of sport and competition to interactions between boys and girls, the meanings and behaviours associated with masculinity and femininity are actively produced within schools. Accordingly, when we are examining the gender differences within mathematics education, and when we examine

the gendered experiences of boys and girls learning maths, it is of fundamental importance to consider the social and institutional contexts that shape these experiences and differences.

Think about your experiences of being in a mathematics classroom, as a teacher or a student - did this classroom construct gender in particular ways?

Were there:

- *discussions of the uses of maths beyond gendered examples (of finance, shopping, etc)*
- *phrases like 'listen up guys' applied to both boys and girls?*
- *pictures of famous male mathematicians on the wall, but not female ones?*

Social Factors Affecting Gender Differences

The initial research that found significant gender differences attributable to biology has been critiqued by feminist scientists. Anne Fausto-Sterling (1993), for example, highlights that this research ignored other scholarship that focused on parental attitudes, teachers' attitudes and experiences of mathematics lessons as reasons for gender differences in maths; scholarship that showed boys' and girls' experiences of learning maths within the same classroom were different (Leinhart, Seewald & Engel 1987). More recent scholarship has continued to examine these issues. For example, Elizabeth Gunderson and her colleagues (2012) highlight that these differences are not the result of biology, or of one single social factor, but are the result of what they call 'early-developing math attitudes' (p. 153). These form from a variety of factors, including aptitude, parental and teacher attitudes, maths-gender stereotypes and expectations of success or failure in maths, among many others.

One of the key ways that girls can be put off maths is through the patronising behaviours of teachers and parents. Sarah Gervais and Theresa Vescio (2012) highlight the detrimental effects of condescending behaviours and attitudes toward women. Distinguishing this 'benevolent sexism' from more overt forms of gender discrimination, they highlight that

even well-meaning acts can have negative consequences if they serve to patronise or belittle women. Accordingly, having equal expectations of boys and girls, praising them in similar ways and not using inappropriate gendered language is of vital importance.

It is worth highlighting at this point that patronising behaviours can often be unintentional and occur from even the most well-meaning of trainees. For example, observing a teacher trainee in school, whom I call Eli here, it was evident that he was reproducing gender stereotypes through how he praised students. During one of his question and answer sessions, he praised boys and girls differently: 'Good girl, Jennifer', Eli said after Jennifer answered a difficult question. 'Brilliant Sarah, good girl', to another student. And when it came to the boys? 'Brilliant John, good man'. Without realising, and in an effort to encourage the boys in the class, Eli was constructing the boys as adults and the girls as children. When I discussed this with Eli after, he was shocked that he was doing it. Eli had never thought carefully about the *gendered* nature of the language he used, and so did not realise the negative effect his teaching might have (see also Burton 1986). Similarly, research shows that even when teachers are trying to give more attention to girls than to boys, they still spend greater time interacting with boys (Younger, Warrington and Williams 1999).

Research also suggests that parental expectations matter a great deal in the desire to pursue maths beyond school. Jacqueline Eccles, Janis Jacobs and Rena Harold (1990) demonstrate that parents of boys had higher expectations of what their child would achieve in mathematics than parents of girls, and that parents of boys also believed their child to be of greater mathematical ability than parents of girls did. In addition to this, they showed that these beliefs were apparent at age 10, with these parents also rating mathematics as harder for girls than boys. Crucially, these beliefs were evident despite there being no difference according to test scores.

It is not only other people's perceptions of mathematics that matter, but also how students themselves think of gender within school. In order to understand this, the concept 'stereotype threat' is important. Stereotype threat refers to the phenomenon by which when

people are reminded of a stereotype about themselves, they perform in such a way that conforms to that stereotype. This has been demonstrated among many groups, including African-Americans who perform worse on intelligence tests when their race is highlighted.

Ilan Dar-Nimrod and Steven Heine (2006) highlight the importance of people's conceptions of *gender* in mathematics ability. In their study, when young women were told that gender differences were the result of biology, they performed worse on mathematics tests than when women were told that they were the result of societal influences. Dar-Nimrod and Heine argue that this highlights the importance of discussing the social elements of gender differences: If female students know that there are minimal biological differences, and that women's relative lack of success in mathematics careers is the result of social issues, some of the negative impacts of gender stereotyping will be ameliorated.

Unfortunately, however, not all issues are based around social constructions of gender and people's perceptions and stereotypes. There are other profound and structural ways in which gender differences in mathematics are produced—most significantly, this involves the very 'nature' of mathematics itself.

Do you reproduce stereotypes of maths and gender in your interactions with others inside and outside of classes?

Do you:

- *say 'good man' and 'good girl'?*
- *give boys and girls equal time in answering questions?*
- *let a student's gender influence your expectations of them?*
- *discuss the same possible maths careers with all capable students?*

The Social Construction of Mathematics and Mathematics Education

Perhaps the prevailing understanding of mathematics in society is that it forms a body of immutable and certain knowledge. Often called the absolutist view of mathematics (Ernest 1998), it is argued that mathematical logic is fundamentally objective and independent of

culture and social attitudes. However, such a view has been critiqued on both philosophical and social levels. Lakatos (1976), for example, highlighted that mathematics is based on a set of foundational principles (or axioms) that are not themselves provable and thus all mathematical proof rests upon *contingent* foundations. He also showed how even proof itself is negotiable – what counts as a valid proof has varied in different times and places.

Paul Ernest (1991) developed this rejection of absolutism to develop a ‘social constructivist’ approach to understanding mathematics. Crucially, it argues that mathematics is situated within the world and is created within particular physical and social realities - that knowledge is created by people rather than discovered. Mathematics has the appearance of objectivity because mathematical knowledge undergoes a process of (scientific) testing to ensure such knowledge is congruent with how reality is experienced; a long process that is subtle and not readily apparent. It is because this process is so slow that the argument is counter-intuitive: Like the theory of evolution, it confounds our everyday thinking because the changes are very rarely noticeable in our lives, occurring over much greater time-spans.

Despite its counter-intuitive nature, this social constructivist approach has been adopted by most scholars of mathematics education. This approach has particular significance for gender, because it opens up opportunities to explore the relationship between the social construction of mathematics and the social construction of gender. Examining the doing of mathematics as a community of practice, Leone Burton concentrated on the implications of the social and contextual elements of mathematics for the people learning it. About this approach, Burton (1995) wrote that

Knowing mathematics would ... be a function of who is claiming to know, related to which community, how that knowing is presented, what explanations are given for how that knowing was achieved, and the connections demonstrated between it and other knowings. (p. 287)

That is, the ability to learn mathematics is dependent on the learner and who (in terms of class, ethnicity, gender, sexuality, etc) that person is, as well as how that person is taught. In

other words, not only is mathematics constructed, becoming proficient at it is inherently social.

The learning of mathematics as social has been discussed by a number of feminist mathematics educators (notably, Becker 1995; Burton 1986; Walkerdine 1988). One of the key themes within these discussions has been understanding how the method of teaching maths impacts on how it is learned and by whom. Joanne Rossi Becker (1995) emphasises the importance both of making connections between components of mathematical learning as well as presenting mathematics as a process and not a set of facts. In Richard Skemp's (1979) terminology, this would be privileging relational learning over instrumental learning (this distinction is elaborated in the chapter by Gwen Ineson and Sunita Babbar). Becker argues that the ongoing failure to do this has disadvantaged women, writing,

the imitation model of teaching, in which the impeccable reasoning of the professor as to 'how a proof should be done' is presented to students for them to mimic, is not a particularly effective means of learning for women. (Becker 1995, p. 169)

Here she is drawing on ideas that men and women, boys and girls, in general, have different 'ways of knowing' with the former favouring abstract or 'separated' ways of knowing and the latter preferring 'connected' ways of knowing in which knowledge is embedded within human relationships. It is clear that pedagogies supporting women's ways of knowing are more compatible with social constructivist than with absolutist philosophies of mathematics. Picking up on this, Jo Boaler (1997, also discussed in the chapters by Hilary Povey and by Anna Llewellyn) showed that girls performed better when taught using investigative pedagogies than in 'traditional' talk-and-chalk classrooms because they had a 'quest for understanding' that the latter could not satisfy, while boys were content to apply rules without understanding why they worked. This work by Becker and Boaler has been hugely influential, however, such approaches in some ways reproduce the oppositional girls vs boys arguments that we saw earlier. As when talking about differences in results between girls and boys, it is difficult here to avoid the tendency to see these differences as 'natural' and to

avoid generalising about what all boys and all girls are like, ignoring the massive differences between boys and between girls, and the equally massive overlap between boys and girls.

Societal Constructions of Mathematics and Mathematicians

Valerie Walkerdine's (1988, 1990) work invites us to think differently about gender and mathematics. She traces the historical processes through which maths became enshrined in the curriculum as being *equivalent* to reason and those through which rationality became conflated with masculinity. She suggests that mathematics fits into a pattern of oppositions that are deeply embedded within Western thought – objective vs subjective, abstract vs concrete, rational vs emotional etc. Masculinity and mathematics line up with the terms on the left hand side of these oppositions and femininity with those on the right hand side (Walkerdine 1990). Following this logic, setting up oppositions between separated and connected ways of knowing and between rule-following boys and understanding-seeking girls can support the reproduction of gender differences in mathematics. Heather Mendick (2006) used these ideas to make sense of gender differences in the take-up of post-compulsory mathematics, showing how the boys she spoke to used mathematics to construct a masculine identity, something which was problematic for girls studying the subject. In addition to the historical patterns Walkerdine analysed, Mendick explored how stereotypes of mathematics and mathematicians in the broader culture and reinforce the associations between mathematics and masculinity.

It is necessary to recognise the impact that cultural conceptions of mathematics and mathematicians have on how people experience and learn mathematics. While our own histories shape our conceptions of what a mathematician looks like – for example, my undergraduate degree in maths has left me with the residing image of mathematicians as middle-aged, eccentric Russian men – it is discourses at a *societal* level that have the greatest impact on how we as a general population think of mathematicians.

Stereotypes of mathematicians have tended to be those of white, old men, with grey beards sat alone in offices thinking deep, abstract thoughts. While this image has changed

somewhat in recent years, Marie-Pierre Moreau, Heather Mendick and Debbie Epstein (2010, and see the chapter by Heather and Marie-Pierre) highlight that it still remains rooted in a gendered version of mathematics. That is, whether it be Russell Crowe in *A Beautiful Mind* or Matt Damon in *Good Will Hunting*, mathematicians are socially-awkward, attractive men who succeed at maths, with their relationships with women disrupted by their tempestuous love affair with mathematics. Furthermore, these men are always positioned as geniuses, as men who ‘just know’ how to solve mathematical problems. Here, maths ability is something that is innate (this is the ‘ability thinking’ that Mark Boylan and Hilary Povey discuss in their chapter). The important point is that the cultural conception of maths among young people remains that it is something that one either can or cannot do. This reproduces the notion that masculinity is something to be passively learnt (instrumentally) rather than a (relational) set of processes and skills to acquire.

What is your philosophy of mathematics and what approach do you use to learn mathematics? Do you think this impacts on how you teach mathematics?

Conclusion

In this chapter, we have examined how the social construction of both gender and mathematics results in gendered inequalities. Highlighting the compulsive attention we pay to gender differences in results in mathematics, and noting the rather small differences that exist at GCSEs, I also argued that there are serious and damaging consequences to how gender is currently treated in maths education. These include fewer women taking maths at higher levels and maths-oriented careers continuing to be male-dominated. Furthermore, I have argued that these differences are being reproduced within maths classrooms – at both primary and secondary levels – and that subtle, nuanced expectations, attitudes and behaviours can result in disparities in later life. Accordingly, it is vital that we consider how we talk about maths and gender in order to ameliorate these differences.

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More on the social determinist side, this book offers a powerful critique of biological research. It argues for social factors and presents a critique of the science of gender studies in an accessible manner.

McCormack, M. (2012). *The declining significance of homophobia: How teenage boys are redefining masculinity and heterosexuality*. New York: Oxford University Press.

My own research on masculinities within schools examines how boys are becoming more inclusive and less 'anti-school'. The second section of the book is devoted to understanding gender in society, masculinities in school and social change

Mendick, H. (2005). *Masculinities in Mathematics*. Buckingham: Open University Press.

Masculinities in Mathematics provides book-length treatment of the gendered nature of mathematics. From looking at how gender is constructed within maths to how boys negotiate these issues, it is an important work in understanding the complexities of gender and maths.

Walkerdine, V. (1998). *Counting girls out*. London: Routledge.

This book provides a detailed empirical and theoretical account of the myths, prejudices and theorizing of the gendered body and mind, and how it intersects with gender in the teaching and learning of mathematics.

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